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salivary, their secretion diluting the poison. The two efferent ducts, one from each set of glands, carry forward and commingle the venomo-salivary products in the main duct: and the stream is then carried by the main duct to the reservoir at the base of the hypopharynx. There is no other exit for the contained fluid. I see muscles apparently inserted on the frame-work of this reservoir (Fig. 1, *m*); but Dimmock seems to think that the hypopharynx is not furnished with muscles. However this may be, the pressure exerted on it by the surrounding parts, when the mosquito inserts its piercing apparatus into the flesh or through the epidermis of a plant, is sufficient to propel the poison through the tubular axis of the hypopharynx into the wound. The reservoir must be furnished with a valve to prevent the reflux of the secretion. The distal orifice of the hypopharynx is not exactly terminal, but sub-apical, as is usually the case with fangs; the very tip is somewhat flattened and sharp, so as to enter easily into and to enlarge the wound made by the adjoining organs.

Careful observations are needed as to the behavior of mosquitoes on plants; as to the condition of the hypopharynx and the glands in the males and in the larvæ. The observations here noted were made on the adult females of Culex (*C. tæniorhynchus* Desv.), and on a species of the allied genus *Anopheles*, which is characterized by its long maxillary palps.

Princeton College, Sept. 18, 1888.

SOMETHING ABOUT CRABS.

BY J. S. KINGSLEY.

CRABBED, crusty, cancer, canker, are terms which at once recall to most persons various disagreeable features and more serious ailments of human beings; to the naturalist they at once suggest the crabs and the group Crustacea to which these animals belong. There must be some reason why the crabs have thus acquired this bad name which goes even farther than indicated above. They are by common consent regarded as ill-tempered, ready to pinch upon the slightest provocation, and anything but straightforward in their actions. When a man begins "to crawfish" (the verb is sanctioned by usage, if not by lexicographers) he does not inspire respect. Yet who cannot recall some surly member of the community who is universally regarded as crusty and crabbed, but who, on more intimate acquaintance, reveals another character, quite at variance with the estimation in which he is popularly held? So it is with the crabs. Their crustiness is all external, and if one be willing to run the risk of an occasional nip, he will find that these much maligned creatures have many attractive aspects, and like the rest of nature they amply repay the time spent in their study.

Intellectually the Crustacea are supposed to rank pretty low in the scale, but it is an open question whether this inferiority be an actual one, or whether it results from deficient observation. We can take the ants into our studies and watch their every motion, but the crabs are not so easily domesticated; captivity does not agree well with most of them, and even with those which can be kept, the surroundings are so strange that we have an element entering the psychological equation the value of which it is not easy to ascertain.

Of all the Crustacea with which I have had personal acquaintance, none are more interesting, either in captivity or on their native beach, than the fiddler crabs, those apparently misshapen forms which throng every suitable stretch of sand along our shores from Cape Cod to the Gulf of Mexico. A picture is well in its way to illustrate the shape and general appearance of an animal, but no picture can present to us the animal in action, nor represent its varying moods and phases. The fiddler, with its quadrate body, its eyes seated on the tips of the slender erectile pedicels, those eight slender, sharp-pointed legs, and that enormous pincer, can readily be drawn, but the changing aspects of the body are beyond the artist's power.

When you draw near the beach where these crabs are abundant, no matter how cautiously you have approached, there is a hurried rush of myriads of these crabs, each scuttling away as fast as four pairs of legs will carry it, to a place of safety. At such a time the appropriateness of the common name is seen. In every direction are the fiddlers, each plying its small claw across the enormous fellow in the most amusing manner. No matter how often seen, one cannot help thinking of the musician—usually bald-headed—away down to the left of the orchestra, who so vigorously saws the bass notes from the viol. Let the latter scamper away, viol and all, as rapidly as does the crab, and the simile would be complete. When, however, you seat yourself and allow the cancrine community to regain its wonted quiet, then you can study these forms to your heart's desire, and see the various occupations. Some are engaged in gathering food, others in building houses. None are idle, but there seems to be no general supervision, each individual following his own inclinations. The holes in which they live vary somewhat with the species. Those on Cape Cod excavate a simple tube leading to a cavity sometimes a foot or two beneath the surface. Further south an allied form appears which arches over the mouth of its burrow with an oven-like roof, beneath the shade of which the proprietor sits and watches for any approaching danger.

These fiddlers are rather remarkable among the crabs in that they live in pairs. Mr. Fiddler is the one who goes about, builds the house, collects the food, and fights the battles and defends the family honor. His faithful spouse is but rarely seen above ground, but what her duties are in her cellar home is a problem yet to be solved. You may at once recognize her by the fact that she lacks the fiddle of her other half. Both of her pincers—hands one might almost call them—are of the same size and resemble the smaller hand of the male, and she uses them indiscriminately in feeding the principal use to which they are put.

The fiddler crabs are usually said to be vegetarians, and, indeed, the greater proportion of their food consists of algæ. They do not, however, confine themselves to this diet, but will eat dead insects or crabs, and, in confinement, they will at times turn cannibals, and prey upon the weaker individuals of their own species. This may be prevented by feeding them often enough and a sufficient amount of vegetable matter. I have had them thrive for months in confinement upon crackers soaked in water, of which, though not their natural food, they appear to be very fond. When thus kept captive they afford very interesting pets, and their actions cause a good many questions. The care is extremely simple. First get your crabs and your jar or box of moist sand, put your crabs in with the sand and the vivarium is stocked. All that is necessary to keep it in running condition is to occasionally moisten the sand, and to supply new food before the old is exhausted. Kept in this way fiddlers will readily live in confinement through the warmer months, and possibly through the winter as well, though I never tried to keep them so long. I had only male fiddlers, and these I kept in the ordinary glass fruit jars which were half filled with sand. This furnished them endless employment, for they were constantly digging new burrows and filling up those dug but a few hours before. Why this dissatisfaction I am not able to say; possibly it was a case of "Cœlebs in search of a wife."

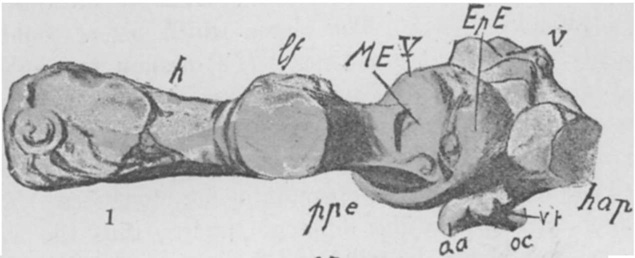
A fight between fiddlers is an amusing affair. When one sees his enemy approaching he immediately puts all his forces on a war-footing. The long-stalked eyes are erected so as to watch every motion of his antagonist; the big pincer furnishes not a bad imitation of the shield with which the soldiers of ancient times protected themselves, while the tension of every nerve is shown in the dainty way in which the eight walking legs trip over the sand, holding the body as high as possible in the air. At last the two meet. There is a clash of arms, each striving to grasp his antagonist and at the same time to protect himself, but might here takes the place of right, and the victor is he who loses the least number of members. There is no surgeon to bind up the wounds, but the amputation of a limb is not such a serious matter here as with human warriors. The yellowish blood which flows quickly coagulates and forms a covering for the wound, and then nature immediately sets about replacing the missing member. The way this is accomplished is so interesting and so different from anything occurring in the lords of creation that it deserves a moment's attention.

The crabs are covered with a hard and unyielding armor which does not admit of growth. So at intervals they shed their shell, and then form a new and larger one, which in turn will be cast to accommodate still further increase of size. In the fiddler crab the first sign one notices of the approaching molt is a splitting of the integument just where the slender tail (which is kept folded beneath the body) joins to the larger anterior portion.

Through the opening thus afforded the crab now withdraws himself, coming forth a soft-shelled, weak, flabby creature. Now he is a pitiable object. The claws, which before could pinch so sharply, are now limp as a rag. His meanest enemy would now find him an easy victim, utterly incapable of the slightest defence. On account of this unprotected condition immediately after molting, all of the Crustacea seek some sheltered spot when about to cast their skin, and hence the operation is not often seen. The process has its differences in the different species; thus the shell of the lobster splits down the middle of the back, while that of the horseshoe crab splits around the sharp front edge, so as to afford the opening through which the animal is to emerge.

There are, however, other processes which precede the splitting of the shell, which need to be mentioned, and which, as they have been most studied in the lobster, will be described as they occur there. First a word as to the nature of the shell. It is what is called a cuticular product. That is, it is not composed of cells like the rest of the body, or like the skin of man, but of a peculiar substance secreted by the cells lying beneath. Its density in various species differs not only with the thickness of this layer, but as well with the amount of carbonate and phosphate of lime which is deposited in it. It is this outer non-cellular layer which is cast at each molt, while the cells secrete a new shell. If one examines closely any crustacean they will see (more numerous and larger in some places) that all over the body there are small hairs, but these hairs differ from those of man in that they consist of the same cuticle as the rest of the body, and have an axis cylinder which arises from the cell beneath. It may also be said that these same hairs are organs of sense. One of the first preparations for a molt is the formation of new hairs and a new cuticle beneath the old one, and these new hairs have to lift and tear away the shell from the underlying shell. It is an interesting fact that in certain reptiles which "shed their skin," there are bristles which lift the old integument in the same way. Another feature to be noticed is the way in which the lobster withdraws its big claw, and probably the same is true of the fiddler, though this is mere surmise. If we examine a lobster we find that the pincer is much larger than the joints which connect it with the body, and it seems impossible that

PLATE XVI.



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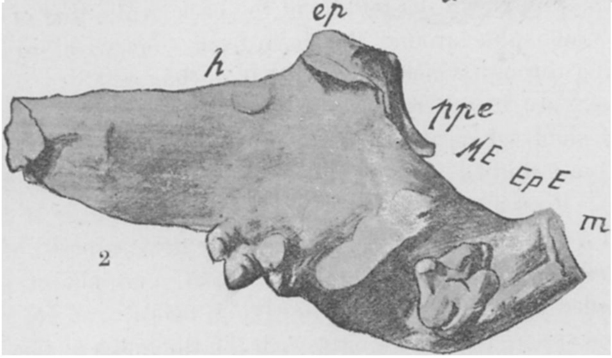

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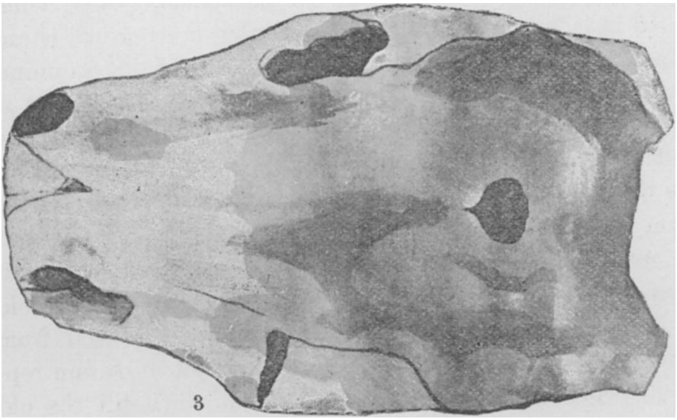

3

Cast of brain-case of Diadectes sp.

Figs. 1 and 2. Cast of cranial cavity, natural size. As the basicranial axis is lost, the inferior outline posteriorly is provisional only.

Fig. 1, from above.

Fig. 2, from the left side.

Fig. 3. Skull of *Diadectes phaseolinus* Cope, from above.

he large muscles which close the pincers can pass through the small flattened rings of the intermediate joints. However, a change takes place in these before molting. There is an absorption of the calcareous matter on the inner surface of these joints, so that they lose their former rigidity and allow the passage of the parts beyond them. In this connection mention may be made of the "crab-stones"—small calcareous bodies occurring on either side of the stomach in Crustaceans about to molt. Although no definite knowledge exists as to the purpose of these masses of lime, it seems probable that they are stores which are to be drawn upon in hardening the new shell. Huxley thinks that this cannot be the case, because these bodies are of inconsiderable size in the crayfish, an argument of but very little weight.

But we are wandering afar from our subject—the way in which lost parts are reproduced in the crabs. Until a molt occurs the wounded veteran has to wander about without the limbs lost in battle, thin stumps seared over by the film caused by the coagulated blood. When the molt takes place we see a change. In the place of the lost leg there rapidly expands a new limb, which is like the old one in all respects except size. It is much smaller, but at the next molt it becomes as large as its fellow. A curious feature connected with the molting is that the lining of the stomach is cast at the same time with the outer shell.

We have explained above the reason why the fiddler crab has received its popular name, but he is in reality a true fiddler. Like many other crabs he has a means of making a noise, and the big claw is his musical instrument. On the inner surface of this member is a row of small rounded tubercles (their position varies with the species), and these can be rubbed against the edge of the shell, producing a note best likened to that caused by rubbing a quill toothpick over a file.

There are other crabs concerning which the popular literature is much greater than that relating to the fiddlers. Possibly more has been written about the hermit crabs than about any others, for certainly no one ever visited the shore without noticing these curiosities. They occur in all seas from the tropics to the poles, but wherever found all exhibit that common characteristic which has given them their name. We have all heard of that old Greek

Diogenes, who made his home in a tub, or, as others will have it, in a cracked amphora, and is it to be wondered that while naturalists were ransacking all ancient history and mythology for names, that the old philosopher should have to furnish a cognomen for some of these, his prototypes? A hermit crab needs protection for the hinder part of his body, for this is covered with a delicate cuticle and could be easily injured. The desired security is sought by inserting this "tail" in the cast-off shell of some univalve mollusc, the curl of the tail and the rudimentary limbs with which it is provided serving to hold the shell tight, and thus protected the hermit wanders over the bottom or along the beach safe from almost any enemy. The little hermits have small houses; the large ones have their larger cells into which they can retire for protection, and, who can say, not for meditation and prayer?

The house-hunting adventures of the hermits have been so frequently described that a repetition is useless. When the body grows too large for the old home a new shell is sought, its dimensions are carefully measured by claws and antennæ, and, if it be thought suitable, moving takes but an instant of time, and the hermit is in a new and larger home. All hermits, however, are not troubled with this frequent recurrence of moving day, for they have living homes, the growth of which is sufficient to accommodate their usual increase in size. They start in life with a borrowed shell, just as do their more familiar cousins of the shore, but a sea anemone helps them later. This latter animal becomes attached to the shell, feeds upon the crumbs dropped from the hermit's table, and grows as he grows. Soon the shell is covered, and then the anemone begins to spread and thus builds a tube for the crab. It goes further, for it absorbs the old shell, and with its own body gives all the protection which the crab needs. Thus the strange partnership goes on; the crab providing food—at least in part—the anemone furnishing the protection. In this respect the latter is far more efficient than the first glance at its soft and skeletonless body would indicate, for it is provided with stinging organs of no mean order, and many a fish is deterred from swallowing crab and all by the nettling it receives from this soft-bodied flower of the sea. A few years ago but a few of these cases of association of hermit crab and sea anemone were known, but more lately the deep-sea dredgings have furnished numerous examples.

This association of forms, which is known as commensalism—a term, a free translation of which would be fellow-boarders—receives numerous exemplifications among the crabs. One form, first described from the Pacific ocean by the late Dr. Stimpson, settles down upon a piece of growing coral, which then proceeds to build a protecting nest about it, leaving only openings for the ingress and egress of the water bringing food and oxygen to the prisoner. Even more remarkable is the case of the shrimp, which so far has only been found enclosed within the glassy network of that beautiful sponge, the "Venus-flower-basket." So strange was this association that when it was first noticed it was thought that those dextrous fingers of the east, which furnish those wondrous ivory carvings and which fashion those curiosity-exciting mermaids, had placed the shrimps within the sponge, and then had closed the opening so skilfully that the detection was impossible. It would now appear that this is not a counterfeit to be be laid at their doors.

Another strange case of commensalism is furnished by some small crabs which are more nearly related to the fiddler with which we started, and of which the little oyster crab is an example. These crabs live inside the valves of oysters, clams and other molluscs, and in olden times quite a pretty myth grew up about them. The delicate Pinna of the Mediterranean (a bivalve mollusc somewhat resembling our familiar salt-water mussel) was eyeless, and in order to escape the jaws of some wandering fish it had to be told when to close its shell. This position of watchman was filled by the little crab which was constantly on the alert, and which in return for its services was protected by the mollusc. This little crab was called Pinnotheres—guardian of the Pinna—and the same name is embodied in the scientific nomenclature of to-day. Relatives of the oyster crab seek other homes. On our Carolina coast is one which lives in the strong tubes built by one of the worms, while in the Pacific are found others which take up their residence in the posterior portion of the alimentary tract of certain sea-cucumbers or holothurians.

The fiddler-crabs are largely air-breathers. In fact, so long as they are in a moist location, where they are in no danger of drying up, they do not need to actually enter the water for weeks or months at a time. In this respect, however, they are equalled, if not excelled, by several species (some their near relatives) which occur in tropical countries, the warmer portions of America possibly being their metropolis. These land crabs are strange creatures, which, like their marine relatives, are provided with gills, but which, unlike them, stay away from the water for months at a time, and which are drowned by submergence almost as quickly as any terrestrial mammal. There is a considerable diversity in their habits. Some frequent the lowlands near some stream or shore, while others, notably in Jamaica and on the Isthmus of Panama, live in the dense damp forests which clothe the highest mountains. They are not easily caught, for they can run with an agility which almost surpasses belief, while their strong pincers have powers of nipping which are not to be despised. Usually but a few are seen at a time, for during the day they rest in their burrows or in holes in the rocks, venturing forth for food only as evening draws near. Once a year, however, they are compelled to visit the shore to lay their eggs. They then appear in incredible numbers, year after year, on almost the same day. They march along in vast armies, turning to neither side for any obstacle, but devouring everything green in their line of march to the sea.

In connection with these terrestrial crabs many interesting physiological experiments are yet to be made. Years ago it was noted that besides the gills, the gill chamber contained a very thick and spongy lining membrane, which was of use in respiration, and several years later Professor Semper made similar observations upon an East Indian species, in which he recognized not only the spongy layer, but also ascertained that it was richly supplied with blood vessels; in short, that this organ, so far as function was concerned, is a veritable lung, though of course of a far different origin from that of the higher vertebrates.